SECRET

ENCLOSURE

A STUDY ON THE LEVEE SYSTEM IN THE HANOI AREA, NORTH VIETNAM

1. The flat delta plain of the Red River area of North Vietnam is densely populated and intensely cultivated, with most of the 6,000 square miles in the plain covered by rice paddies. From the Hanoi area, the delta fans southeastward to the Gulf of Tonkin, sloping gradually from an elevation of about 8 meters above sea level near Hanoi to less than 1 meter near the coast. In the central part of the delta plain, the most important terrain feature is the natural "levees" of alluvial deposits along the banks of the streams. Near Hanoi, these rise to 3.3 meters above the surrounding terrain; farther downstream, they decrease to about 1 meter. They are one to two miles wide and slope very gradually from a crest near the stream. These natural levees divide the delta into a series of shallow, saucer-shaped basins (Appendix A) in which water tends to pond and drainage is difficult. The Hanoi urban complex is bounded on the north by the Red River and its Song Duong (Canal-des-Rapides) distributary. Southward of its junction with the Song Duong, the Red River divides Hanoi into eastern and western sections; the central city proper lies on the west bank (Appendix A).

2. Practically the entire delta would be flooded yearly if it were not for the extensive system of large levees which have been built along the main streams with smaller levees along the minor channels. At Hanoi, the Red River main levees rise to an elevation of about 13.5 meters above mean sea level, or about 12 meters above the river bed. The height of the levee above flood stage is about 1.5 meters. Widths of the levees range from 7 to 9 meters at the tops to as much as 45 meters at the base (Appendix B).

3. The water surface elevation of streams in the Delta area reflects seasonal variations, with a summer maximum in July or August, and a winter minimum in March. During the typhoon season, runoffs cause flash floods in which the water level rises 2 to 5 meters in a few days, and then quickly receeds.

4. The levee system has practically eliminated flooding by natural causes, but this does not preclude induced flooding by breaching of the levee system in selected locations. The extent to which flooding operations would be successfully effected is highly contingent on (1) the existence of favorable Red River stage levels at Hanoi, and (2) the timing, accuracy and effectiveness of breaching operations.

a. To achieve maximum effectiveness, the optimum water level for commencement of breaching operations would be when the river stage approaches the top of the levees, approximately 13.5 meters above mean sea level at Hanoi; but only during infrequent major floods does the stage exceed 11 meters. Considering the probabilities of occurrence, the most suitable breaching stage was assumed to be at the 10-meter level (Appendix C).

b. Optimum effectiveness of breaching operations is contingent upon proper timing. During the likely flood period, frequent aerial reconnaissance and daily collection of river stage data by covert means and by monitoring of the Hanoi radio (which periodically broadcasts river stage levels when flood conditions approach dangerous levels) would be necessary to determine when conditions would be favorable for breaching operations.

5. Breaching of the levees could be effected in one of two ways. First, commando-type demolition raids of internal sabotage might be employed, or breaching could be achieved through air strikes. Damage objectives of the air strikes would be cratering across the entire crown of the levees at sufficient depth, so that crater lips would be below the water level in the river channel. If the desired cratering effect were achieved, the scouring action of water rushing through the initial breach would rapidly deepen breach to the base of the levee. The breach also would progressively widen to an unpredictable but appreciable width. The velocity of the flow (and its destructive effect) would be greater within the flooded area close to the location of the breach, but would diminish progressively with distance from the breach. The water elevation also would tend to decrease with distance from the breach, because of the hydraulic gradient associated with flow of water and because of the loss of head created by flowing over, through, or past obstacles such as embankments, culverts, or other constricting structures. Thus, breaches should be located as close as possible to the specific areas selected for flooding.

6. Four breach points have been selected as suitable locations to portray the probable maximum flooding effect on the study area--three breach points for Compartment A and one breach point for Compartment B (Appendix D). The aerial photographs illustrate the wide variations between low and high water river conditions available. On the insert, illustrating high water level conditions of July 1964, the water level approached to within 2 meters of the top of the

levee (Appendix E). Simultaneous breaching at indicated points in Compartment A would result in rapid flooding, with relatively swift current velocities and consequent maximum damage. A single breach accomplished under optimum stage levels in Compartment A or B would have immediate, positive effect in the general area of the breach; farther from the breach, slower pending would occur, contained somewhat by embankments and secondary dikes. Breaching at multiple points would result in more rapid rise of water levels throughout the compartments, maximizing damage, minimizing opportunity for dispersal or salvage operations, and neutralizing the effectiveness of countermeasures--e.g., defensive breaching of upstream sections of the levees systems by the DRV to divert water into Compartments C and D thereby reducing flood stages at Hanoi, perhaps by as much as 1 or 2 meters.

7. To breach, earth levees can be effectively damaged by cratering the crest far enough below the water level so that there is sufficient head and volume of water to continuously deepen the breach by erosion. The rapid increase in thickness caused by the gently sloping sides of the levee makes it vulnerable to breaching or even effective weakening by bombs striking anywhere except on or near the crest.

a. Waterline thickness of the levee at the 10 meter flood stage is approximately 80 feet. Neither a single 1000 lb. GP nor a single 2000 lb. GP is capable of cratering the complete thickness of the levee at the waterline. The principal problem then is to obtain a sufficient number of closely spaced hits so that the overlapping craters will cut a channel completely through the levee below the water level.

b. The 1000 lb. GP dropped from 4000 feet altitude at 350 MPH will penetrate about 10.1 feet in average soil and produce a crater about 37 feet in diameter. Assuming that 11 bombs are dropped in train with an intervalometer setting so as to achieve a 30 foot spacing between bomb impacts, and a CEP for the center of the train equal to 200 feet, the following table shows weapon requirements for three assurance levels of cutting the levee at the 10-meter stage.

10 METER FLOOD STAGE

Assurance	No. of Trains	No. of 1000 lb. GP Bombs
50%	5	55
75%	6	66
85%	8	88

c. The 2,000 lb. GP will produce a crater about 48 feet in diameter and thus would be the best available GP bomb for an attack in which the bombs would be individually aimed or dropped. It is estimated that it would be necessary to concentrate five hits with 2,000 lb. bombs in an area 50 feet wide across the crest of the levee in order to be sure of a complete cut at the water line. The following table shows the weapon requirements in terms of the probability of 3, 4, or 5 hits in the 50 by 80 foot vulnerable area, assuming a CEP of 200 feet.

10 METER FLOOD STAGE

Weapon Requirements (No. of 2,000 lb. GP Bombs)

Probability	3 Hits	4 Hits	5 Hits
.50	125	170	240
.70	170	220	300
.85	230	290	360

It is seen that even if three hits in the vulnerable area would cut the necessary channel, the weapon requirements are considerably greater than those estimated for train bombing in paragraph b, above.

8. Artificial flooding of the study area is feasible. To achieve maximum effect would require successful breaching of levees timed to coincide with optimum river stage levels, which are most likely to occur only during the June through August period. Breaching of the levees would be difficult and require heavy bomb loads and accurate delivery.

It is estimated that approximately 26 military and key industrial installations would be subjected to inundation and flood damage (Appendix F). Duration of inundation, extent of damage and recuperability would depend upon such factors as the height of flooded waters at breaching, elevation of the target and nature of the target. Flooding would have varying socio-economic effects in terms of dislocation of the population, loss of life, and disruption to agriculture.